The Southern Pulse Agronomy Program conducts applied research and development to address key management issues associated with new varieties of pulse crops (lentil, field pea, chickpea, faba bean and lupin). Various field sites across all rainfall zones in the cropping region across south-eastern Australia are utilised.

This report provides a ‘snapshot’, highlighting results from three of the research topics which had significant interest from industry in 2013.

The research discussed here only forms a small component of all research conducted in 2013. A detailed report covering all trials will be available later in the year.

Group B herbicide tolerance in lentil

Profitable medium sized kabuli chickpeas

Inoculation of pulses on acidic soils

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1. Lentil Group B Herbicide Tolerance, Mid North, South Australia.
Mick Lines & Larn McMurray, SARDI

Aim
To identify levels of tolerance to “residual” Group B herbicides in lentil cultivars with improved tolerance to Group B herbicides.

Treatments
Varieties: Nipper, PBA HurricaneXT and CIPALI 209
Herbicides: Chlorsulfuron, Metsulfuron-methyl, Triasulfuron and Imazapic. Residue levels were simulated by allocating half, quarter and eighth rates of an appropriate application rate for each chemistry. All herbicide products and rates are off-label and experimental only, and rate identification has been withheld.

Other Details
Sowing date: 25th May 2013
Timing: All herbicides were applied at the post-sowing pre-emergent (PSPE) stage. This was implemented to avoid removal of the herbicide from the furrow due to soil throw, and better simulate herbicide residues. The trial was levelled and rolled immediately post-sowing to leave a smooth soil bed.
Conditions: Treatments were applied to moist soil, and received 25mm rainfall within 12 hours of application.
Row Spacing: 22.5cm (9 inches)
Stubble: Nil
Fertiliser: MAP + Zn @ 90 kg/ha at sowing
Plant Density: 120 plants/m²

Background
Previous work has shown that a high level of crop safety exists in PBA HeraldXT and PBA HurricaneXT to both post-sowing pre-emergent (PSPE) and post-emergent (PE) applications of Imazethapyr. This has resulted in a permit for use of this chemistry in these varieties. A high level of crop safety was found for most but not all of the Group B herbicides tested, however these varieties have shown improved tolerance to all Group B chemistries tested compared to intolerant varieties (Nipper and PBA Flash).

With Sulfonylureas being a common additive to many summer knock-down sprays, there is intense interest in exploiting this improved tolerance to these chemistries in the form of soil residues. However, little work has been done in this area and variable responses have been generated to date. This trial was put together immediately prior to seeding, in consultation with key agronomists in South Australia. Due to the timing constraints, treatments were applied PSPE and may not fully simulate soil residues, however it does still highlight some of the sensitivities associated with certain Group B products. Herbicides were applied PSPE to a smooth soil surface instead of incorporated by sowing (IBS) to avoid removal of the herbicide from the furrow due to soil throw, and to better simulate herbicide residues. Post-treatment conditions were ideal for simulating residues, with 25mm rainfall falling within 24 hours of application. A number of rates were applied to account for seasonal and site specific effects on residual herbicide levels (eg rainfall, soil temperature, microbial activity and soil characteristics), and to provide information for various seasonal scenarios.

Results and Interpretation

Plant Damage
The intolerant variety Nipper showed significant plant damage in all herbicide treatments (Fig. 1). Chlorsulfuron and Triasulfuron caused the most damage but Metsulfuron and Imazapic still produced high levels of necrosis at all rates. Chlorsulfuron and Triasulfuron were the only chemistries to cause significant plant damage in the tolerant variety PBA HurricaneXT. This only occurred at the highest application rate in Chlorsulfuron, but occurred in all except the lowest rate of Triasulfuron. The breeding line CIPALI 209 generally showed intermediate levels of tolerance compared to Nipper and PBA HurricaneXT for all chemistries except Imazapic, which produced no significant damage.

Grain Yield
The intolerant variety Nipper showed significant yield loss from all application rates of the more damaging herbicides, Chlorsulfuran and Triasulfuran (Fig. 1). However, despite showing significant levels of plant damage at all rates, Nipper only showed yield loss from the highest application rates (R) of Metsulfuron and Imazapic. The tolerant variety PBA HurricaneXT showed yield loss from Chlorsulfuran at the two highest rates, Metsulfuron at the highest rate, and Triasulfuron at all except the lowest rate. Imazapic did not cause significant yield loss to PBA HurricaneXT at any application rate tested. The breeding line CIPALI 209 generally showed intermediate levels of tolerance compared to Nipper and PBA HurricaneXT for Chlorsulfuran, Metsulfuron and Triasulfuran. Similarly to PBA HurricaneXT, Imazapic did not cause significant yield loss to CIPALI 209 at any rate tested.

Key Findings and Comments
- This trial shows higher yield losses associated with the use of certain products than generated in previous trials. This is likely due to a combination of the soil conditions (highly active, light textured and high pH soil with no stubble cover), application method (applied PSPE), and seasonal conditions (dry finish which did not enable plant recovery).
- The application method adopted in this trial may not fully simulate herbicide residues. This is due to the likelihood of concentrated herbicide occurring in the upper soil layer as a result of applying treatments PSPE compared to a summer spray application. In a summer spray application herbicides are likely to wash into the soil profile by rainfall between application and seeding. Significant rainfall immediately after the PSPE application may have helped to reduce this effect in these highly soluble products.
- Herbicide residues remaining at seeding are likely to be highly seasonally variable due to the effect of rainfall, soil temperature and microbial activity on herbicide breakdown. A range of rates were applied to account for seasonal variation, with the highest rate reflecting the likely worst case scenario.
- PBA Herald XT was not included in this trial. Tolerance of both PBA HeraldXT and PBA HurricaneXT is under the same genetic control, and both varieties have shown similar levels of tolerance in previous trials.
Figure 1. The effect of various Group B chemistries and application rates on damage score recorded 8 weeks after sowing (0-50 = increasing levels of chlorosis; 50-100 = increasing levels of necrosis and plant mortality; 100 = whole plot dead) and grain yield (t/ha) of lentil lines at Pinery, 2013. Damage score: 0-50 = increasing levels of chlorosis. 50-100 = increasing levels of necrosis and plant mortality. 100 = whole plot dead.

- Some treatments showed low levels of plant damage that were not significant, but still incurred a significant yield loss. PBA HurricaneXT showed a 50% yield penalty from use of Chlorsulfuron at 1/2R, where only insignificant damage symptoms were observed. This yield loss was likely to have been caused by the effect of delayed flowering and maturity and the reduced ability to recover from biomass reduction, due to the dry season finish. This response, where a herbicide causes yield loss without causing mortality, has been observed in previous trials and is sometimes associated with the use of other products such as Metribuzin and Flumetsulam (Broadstrike®). Hence, absence of visible damage associated with using certain products does not necessarily mean there will be no yield penalty. Furthermore, identification of damage symptoms is likely to be more difficult at a paddock scale, where there is often no untreated control, than at trial scale where treatments can be accurately compared.

- The herbicide tolerant varieties/lines PBA HurricaneXT, PBA HeraldXT and CIPAL1209, show significantly improved tolerance to all Group B herbicides compared to intolerant lentil varieties. However, there is a range of tolerance to these chemistries within these lines, and they do not show the same level of tolerance to Sulfonylureas as is observed for Imidazolinone products. Previous work has shown that CIPAL1209 has improved tolerance to Imazapyr compared to PBA HurricaneXT and PBA HeraldXT, which show better tolerance to Sulfonylureas than CIPAL1209.

- Chlorsulfuron and Triasulfuron were the most damaging treatments in the trial, with Triasulfuron causing yield loss in PBA HurricaneXT even at the 1/4R rate. Metsulfuron appears to be the safest of the Sulfonylurea chemistries tested. Further work is required to confirm whether PBA HurricaneXT shows sufficient tolerance to residual rates of this chemistry to support application for registration of Group B tolerant varieties.

- It is important to note that product label rates, plant-back periods and directions for use must still be adhered to.

- Further work is required to validate these results across seasons. This will include treatments applied as a summer spray to better reflect herbicide residues.

Key Point - XT lentil varieties show improved tolerance to residual Group B herbicides, but can still show significant crop damage and high yield losses.
Aim
To investigate the impact of sowing date and row spacing on the grain yield, size and profitability of a range of kabuli and desi chickpea varieties.

Results and Interpretation

Background
While grain yield is important in chickpeas, overall grain size and the proportion of seed within each size category for kabuli’s is critical determining the potential profitability of a variety. More recently it has been apparent that the smaller sized kabuli’s, like Genesis090, can be difficult to market, particularly when there is oversupply in the world market. Medium and large kabuli’s potentially could offer growers greater returns and ease of marketing, provided grain yields are similar to the traditional smaller varieties and high proportion of larger seed is achieved.

Varieties:
Kabulis - Genesis090, PBA Monarch, Genesis™Kalkee; Desi - PBA Striker.

Sowing dates (2012): 4 May (Early), 5 June (Mid), 26 June (Late).
Row spacing (2013): 18cm, 36cm and 72cm

Other Details:
Row Spacings/Stubble (2012): 30 cm row spacing, inter-row, standing stubble.
Sowing date (2013): 1 May
Fertiliser: MAP + Zn @ 60 kg/ha at sowing.
Target Plant Density: 30 plants/m².

Grain Size
Medium and large kabuli’s potentially could offer growers greater returns and ease of marketing, provided grain yields are similar to the traditional smaller varieties and high proportion of larger seed is achieved.

Grain Yield
2012
Grain yields, ranged between 1.0 and 1.8 t/ha (Fig. 1). There was no interaction between sowing date and variety, however the main effects were significant. There was little difference between the May 4 and June 5 grain yields, however delaying sowing until June 26 resulted in a 30% reduction for the desi, PBA Striker; and a 36-39% reduction for the kabulis, Genesis090, Kalkee and PBA Monarch. All varieties generally had similar yields, particular at the first two sowing dates, is reflective of the mild conditions experienced during the reproductive phase of crop development.

2013
Grain yields were similar to 2012 for PBA Striker, slightly less for Genesis090 and PBA Monarch and reduced by approximately 20% for Kalkee (Fig. 1). There was no significant response to row spacing, however the yield of varieties varied significantly. PBA Striker, had the highest yield, 5%, 13% and 29% higher than PBA Monarch, Genesis090 and Kalkee, respectively. It is believed that the relatively low yields at this site for chickpeas in 2013 was because as indicated above temperatures often fell below the critical levels for seed set.

Profitability

Net income based on the following grain prices: Desi = $450/t; Kabuli = <7mm-$330, 7-8mm-$550, 8-9mm-$750, 9-10mm-$850, 10-11mm-$1000 with fixed management costs of $220/ha and fungicides at $15/ha per application (No. of sprays based on varietal resistance: resistant (Genesis090) = 1, moderately resistant (PBA Striker) = 2, moderately susceptible (PBA Monarch and Kalkee) = 3).

2012
Net income estimates ranged from approximately $305/ha for PBA Striker sown June 26, up to $1070/ha for PBA Monarch sown May 4 (Fig. 1). All the Kabuli varieties were more profitable than the desi PBA Striker due to the estimated price differentials. The medium (PBA Monarch) and the large (Kalkee) seeded kabulis were more profitable as yields were similar to other varieties and grain size and quality was excellent (discussed below).

2013
Despite showing grain yield 5% less than PBA Striker and higher production costs because of its increased susceptibility to ascochyta blight, the estimated net income of PBA Monarch ($920/ha) was 40% higher, because of higher prices received for grain (Fig. 1). It was also 25% higher profitability than the small kabuli, Genesis090 and large kabuli, Kalkee.

Grain Size
While sowing time can have an effect on the relative number of seed in each size category, the primary driver is varietal, so in this article we have only presented the data from Curyo in 2013 to highlight the consistent differences observed. In the smaller kabuli, Genesis090, 60% of the grain was less than 8mm and 40% in the 8-9mm class (Fig. 2). Conversely the medium kabuli, PBA Monarch produced only 20% of seed less than 8mm, with 65% in the 8-9mm class and 15% in the 9-10mm class. The large kabuli produced only 10% of seed less than 8mm, with 40% in the 8-9mm and 50% in the 9-10mm classes.
The net income from PBA Monarch was between $200 and $300/ha greater than Genesis090 in 2012 and 2013 at Curyo, even though grain yields were similar. This is primarily due to a greater proportion of seed in the 8-9mm and 9-10mm categories than Genesis090. Seed in these categories receives $200-$300/t more than the 7-8mm category. It is also anticipated that seed in the 8-9mm and 9-10mm categories will be easier to market, reducing the need for growers to store seed on farm for long periods, as has been the recent history for Genesis090.

Currently the large seeded kabulis do not appear to have the yield stability required to be successfully produced in dry areas consistently, as indicated by the marked drop in yields and profitability of Kalkee in 2012 compared with 2013.

Earlier sowing is important for maximising grain yield and profitability of chickpeas in the Southern Mallee. Delaying sowing to June 26 resulted in losses of between $250 and $450/ha in comparison with May 4 and June 5 sowing dates.

Chickpeas appear to be widely adaptable to a range of row spacings with no difference observed from 18cm to 72cm in the trial in 2013. This replicates the results of many previous trials in the medium and lower rainfall zones of Victoria.

Further research is ongoing to investigate a larger range of medium kabulis and their adaptation and yield stability in a range of environments. If consistent seed size and grain yields can continue to be replicated across seasons, the medium kabulis could prove to be very profitable in the southern mallee, particularly given the lower disease risk due to the drier conditions generally experienced, compared with traditional production zones like the Wimmera.

PBA Monarch (CICA0857)
PBA Monarch is a high yielding medium sized kabuli chickpea. It is particularly well adapted to the shorter medium rainfall environments of south eastern Australia, due to improved adaptation through earlier flowering and maturity compared to Genesis090, Almaz and Kalkee. It has shown a consistent yield advantage of 5 - 13 % over current medium and large seeded kabuli varieties. It also has shown similar yields but larger seed size than the small sized Genesis090. Seed size is predominantly 8 - 9 mm (larger than Genesis090 and similar to Almaz).

PBA Monarch has a semi spreading plant type and is early flowering and maturing (earlier than Genesis090 and Almaz). It is moderately susceptible (MS) to ascochyta blight (similar to Almaz and Genesis Kalkee) but more susceptible than Genesis090 and susceptible (S) to phytophthora root rot. Seed is available through SeedNet.

Acknowledgments
I wish to thank Kristy Hobson, PBA Chickpea breeder, for her ongoing advice and support of this research.

Key Point - The increased seed size of the kabuli variety, PBA Monarch, resulted in net income $200-300/ha greater than Genesis090.
3. Effect of inoculant formula and soil moisture condition on nodulation of pulses on an acidic red-brown earth at Wagga in southern NSW

Eric Armstrong, Eric Koetz, Luke Gaynor & Gerard O’Connor

Aim
To compare different inoculant formulations for effectiveness on nodulation and yield of field pea, faba bean, lentil and chickpea under varying soil moisture conditions on an acidic red-brown earth at Wagga in southern NSW.

Treatments
Pulses: PBA Oura field pea; PBA Slasher chickpea; PBA Farah faba bean; and CIPAL0901 lentil.
Inoculants: Granular (Becker & Underwood), liquid (peat slurry into row) and nil.
Sowing dates: 9 May (dry) and 7 June (moist).

Background
The impact of pulses as a break crop and as a net contributor of biologically fixed N across all farming systems of Australia is highly dependent effective nodulation. Pulses, particularly chickpea, field pea, lentil and faba bean, have evolved from world centres dominated by alkaline soils. This reflects their current distribution and production in Australia, which is largely concentrated in South Australia, Victoria and northern NSW. Rhizobia are similarly adapted to alkaline soils and can survive for many years in these regions without the need to inoculate as a routine cultural practice. This situation however is somewhat different in southern NSW, where the farming system is dominated by acidic red-brown earths and Rhizobia do not survive and routine inoculation at sowing is essential. Since dry autumns have become increasingly common over the past decade, farmers are now questioning the effectiveness of inoculating pulses using traditional methods under dry sowing conditions. Given this background and the advent of different formulations of inoculants, this study was undertaken to assess nodulation using different inoculate formulations on a dry and wet acidic red-brown earth at Wagga in southern NSW in 2013.

Climate
Well below average summer and autumn rainfall preceded this trial, resulting in low soil moisture profiles and a dry seedbed for sowing and production of the following crop. Growing season rainfall (April–Oct) was 24% below average and maximum and minimum temperatures were 2.1°C and 1.4°C above long term average temperatures, respectively. Despite these dry and unseasonal warm conditions, pulses grew disease free and yielded relatively well. Extreme frost events occurred in mid October resulting in mild to severe frost damage (up to 20% of pods).

Methods
Two sowing dates were selected to reflect different soil moisture conditions: early (9 May 2013) into a dry seedbed (following a very dry summer receiving no effective rainfall); and late (7 June 2013) when intervening rain resulted in a moist seedbed. At each sowing, the un-inoculated control was sown first in an effort to prevent any residual contamination from the other formulations. The liquid-based formulation then followed, made by mixing a peat-based product with water then injecting through micro-tubes directly into the furrow just behind the seed at sowing. Finally, the granular-based formulation was sown with the seed through the cone seeder. While Rhizobia were inoculated into a very dry soil at the first sowing, they did receive 29mm of rain some five to eight days later.

Therefore, crucial events affecting survival of Rhizobia and effectiveness of nodulation of each of the pulses in this experiment were: varying levels of soil moisture at sowing; subsequent rainfall; the different formulations of inoculant; and finally the acidic nature of our local soils (a red-brown earth - see Table 1).

Only one variety of each of the main pulses was chosen (see Treatments above), and the trial was replicated three times and managed according to best cultural practices for the region. Cultural practices adopted included fertilizer of 80 kg/ha of grain legume super (0:15:7), a 30cm row spacing and a pre-sowing tank mix of Glyphosate (1.5L/ha) + Terbyne (1Kg/ha) + Stomp (2L/ha) & Avadex (2L/ha) for weed control.

Table 1. Soil chemical analysis, Wagga Wagga 2013

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>pH (CaCl₂)</th>
<th>Al Sat %</th>
<th>Nitrate N</th>
<th>Ammonium N</th>
<th>P (Colwell)</th>
<th>CEC</th>
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<tr>
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<td>2.5</td>
<td>11</td>
<td>1.5</td>
<td>38</td>
<td>5.62</td>
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<tr>
<td>10-20</td>
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<td>9.7</td>
<td>8.3</td>
<td>0.8</td>
<td>11</td>
<td>5.35</td>
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</table>

Nodule Scores
Ten plants with intact roots to 20cm were collected from each plot eight weeks after emergence to assess nodulation. Plants were soaked in water then soil removed to assist assessment. Nodule ratings were conducted using a scoring system developed by Corbin et al. (1977) - see Table 2 below. Scores 0-1 are inadequate and reflect very low nodule numbers; scores 2-3 are adequate; and scores 4-5 high and show excellent nodulation.

Table 2. Nodule classification ratings used at Wagga in 2013 (see Corbin, E.J., Brockwell, J. and Gault, R.R. 1977 Nodulation studies on chickpea (Cicer arietinum), Australian Journal of Experimental Agriculture and Animal Husbandry, 17, 126-134).

<table>
<thead>
<tr>
<th>Nodule score</th>
<th>Nodule number on crown</th>
<th>Nodule number on laterals</th>
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<tbody>
<tr>
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<td>1</td>
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</tr>
<tr>
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<tr>
<td>2</td>
<td>Few</td>
<td>0</td>
</tr>
<tr>
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<td>3</td>
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<td>4</td>
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<tr>
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</table>
Southern Pulse Agronomy Research Snapshot 2013

Grain yield fell on average by around 30% when sowing was delayed from 9 May to 7 June. Field pea was the highest yielding pulse.

Key Findings and Comments
- Field pea, faba bean, chickpea and lentil do not effectively nodulate on acidic red brown soils in southern NSW without inoculation.
- Granular and peat-based (as water injected) inoculants were equally effective in nodulating field pea, chickpea, faba bean and lentil.
- Nodulation was equally effective from sowing into either a dry or wet soil at Wagga in the 2013.
- Nodulation was poorest in lentil.

Acknowledgements
We would like to thank Jon Evans (Technical Assistant) for assistance with trial management and field assessments.

Key Point - Be sure to routinely inoculate field pea, faba bean, chickpea and lentil on acidic soils.
About Us
Southern Pulse Agronomy is a tri-state research program lead by DEPI Vic and funded through GRDC, DEPI Vic, SARDI and NSW DPI. The current project, from which research results presented here have been generated, is entitled 'Expanding the Use of Pulses in South-Eastern Australia' (DAV00113).

Program Objective
To undertake research aimed at increasing on-farm productivity, reliability and profitability of lentil, field pea, chickpea, faba bean and lupin in south eastern Australia. The program delivers specific crop management practices that optimise yield and quality and minimises production risks of new varieties. Further, new traits are identified and explored for each pulse that will provide future benefits to each breeding node of Pulse Breeding Australia.

Vision
To develop profitable and sustainable pulse crops, to increase their adoption to between 15-20% of total crop area planted, increase their average yields from 1.0 to 1.5 tonnes per hectare and reduce overall input costs.

The Southern Pulse Agronomy Team

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Pulse Breeding Australia: Who gratefully provide the new pulse varieties seen in these reports.

More information about these varieties is available from the PBA website (http://www.grdc.com.au/Research-and-Development/Major-Initiatives/PBA)

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